National Aeronautics and Space Administration

technology opportunity

Web Growth of Silicon Carbide Surfaces

Improved yield and performance for wide bandgap electronic devices

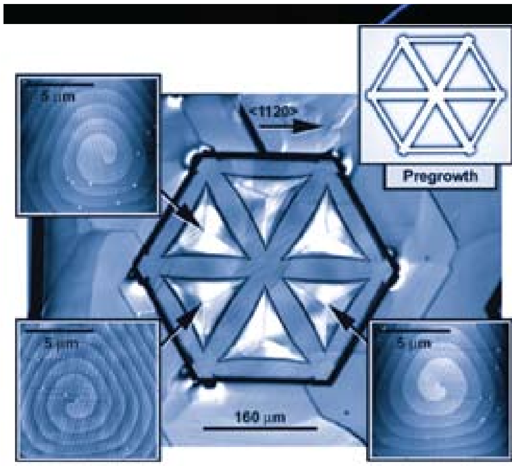

Figure 1. Enclosed “hexagon” mesa, showing dislocations located at points of final coalescence.

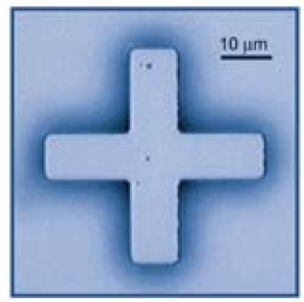

Figure 2a. “Open” cross mesa shape prior to epitaxial growth.

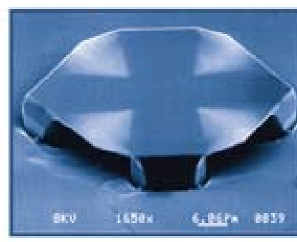

Figure 2b. SEM of mesa following epitaxial growth.

Material quality is a major factor affecting the performance of many non-silicon semiconductor electronic devices. Poor quality material, such as material containing a high level of defects, decreases device performance and shortens device lifetime. Technology developed by researchers at NASA Glenn Research Center (GRC) limits or eliminates dislocation defects, resulting in the higher quality material necessary for more robust small-area devices, ones with higher performance levels and increased yields. GRC’s technology provides for web growth of silicon carbide (SiC), ideal for use in wide bandgap electronic devices.

Benefits

- **Improved device performance:** Decreases the number of possible defects (including dislocations) in the SiC material.
- **Extended device life:** Provides longer life for SiC-based electronic devices and semiconductors by controlling or eliminating dislocation defects.
- **Decreased unit cost:** Decreases defects in the SiC and makes a higher production yield of electronic devices possible.

Applications

- Surface-sensitive SiC devices:
  - – Metal/oxide semiconductor field effect transistors (MOSFETs)
  - – Schottky diodes
- Wide band gap III-nitride devices built on SiC substrates:
  - – Blue lasers
  - – Blue LEDs (light-emitting diodes)

Technology Details

How It Works

The first step in web growth of SiC is to etch arrays of mesas into commercially available SiC material. Mesas for web growth, created by researchers at GRC, have branched geometries, enabling thin lateral cantilevers to extend from the branches and grow together as material is deposited on top of the mesa. This process forms the webbed surface of SiC, free of dislocation defects. As additional material is deposited, the web extends to cover the entire area between the branches.

Why It Is Better

GRC researchers have documented that "enclosed" mesas (Figure 1) behave differently than "open" mesas (Figures 2a and 2b). "Enclosed" mesa geometries relocate and combine dislocation defects to the point of final cantilever coalescence. Based on the principle of Burger's vector conservation, all of the dislocations contained in the enclosed region of the substrate combine into a single dislocation defect in the webbed roof, at the point of final roof coalescence. Because the remainder of the webbed roof is defect free, devices can be fabricated to avoid the known dislocation site. In addition, the dislocation contained in the web roof provides new steps for continued epitaxial growth. The technique has the effect of reducing the number of dislocations in local regions of crystal by combining multiple dislocations into one. In "open" mesa geometries, defects that are contained in the substrate area between the branches will overgrow the dislocation, resulting in an atomically flat web surface. Small-area devices can be deposited anywhere on this defect-free crystal surface. This technique reduces the number of crystal dislocations by terminating those that fall between branches.

Patents

GRC has patented this technology: U.S. Patent No. 6,461,944 and No. 6,783,592.

Licensing and Partnering Opportunities

This technology is part of NASA's Innovative Partnerships Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to inquire about the licensing possibilities for the Web Growth of Silicon Carbide Surfaces technologies (LEW-17116-1 and LEW-17237-1) for commercial applications.

For More Information

For more information about this and other technology licensing opportunities, please visit:

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